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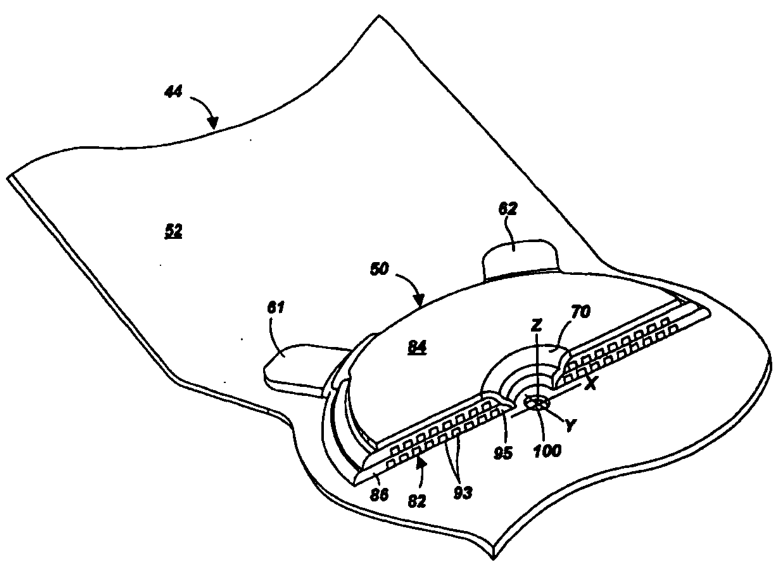

(57) Abstract

A coil assembly for use in an optical or a magneto-optical data storage system having a slider and an optical assembly, includes a dielectric substrate. The coil is either bonded to, or formed on the dielectric substrate, and terminates in two bonding pads. In one embodiment the dielectric substrate is flexible and is made of alumina. The coil is surface mounted on the underside of an optical assembly and/or a slider by means of available techniques, such as an adhesive. The coil assembly includes two tooling, alignment and handling holes, and an optical passage defined at the center of the coil for allowing an optical beam to pass through. The coil assembly has compact, low mass, and high vertical magnetic field characteristics, and allows direct overwrite at a low flying height, with precise control of the focal plane of the optical assembly.

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ELECTRO-MAGNETIC COIL ASSEMBLY

BACKGROUND OF THE INVENTION

This invention generally relates to optical and magneto-optical data storage systems, and in particular to an electro-magnetic coil assembly for use in optical and magneto-optical data storage systems. The coil assembly may be used in other applications, including but not limited to wireless telecommunications, sensors, and inductors.

Optical and magneto-optic data storage systems store great quantities of data on a disk. Data is accessed by focusing a laser beam onto the disk and detecting the reflected light beam. Writing onto a MO disk is a multi-pass operation including an erase cycle and a writing cycle. In the erase cycle the track or sector on which data is to be written is first erased by energizing an electro-magnetic coil that applies an external magnetic field. In the writing cycle, the external magnetic field is modulated and a laser beam is pulsed to write data by selectively reversing the polarity of the domains where necessary. The erase cycle significantly reduces disk drive performance. There is therefore a need for an electro-magnetic coil assembly that enables a single-pass direct overwrite of data onto the MO disk.

A conventional electro-magnetic coil is generally large and bulky, and as such adds undesirable mass to a head flying above the MO disk. Alternatively, the conventional electro-magnetic coil is formed on the slider body, thereby adding complexity to the head assembly process and lowering the manufacture yield. It would therefore be desirable to have a new electro-magnetic coil assembly and a method of assembly that address the concerns facing conventional coil designs.

SUMMARY OF THE INVENTION

One aspect of the present invention is to provide an electro-magnetic coil assembly for use in, and attachment to a surface of an optical or magneto-optical data storage system. The coil assembly has compact, low mass, and high field characteristics, and allows direct overwrite when attached to a low flying slider, with

precise control of the focal plane of the optical assembly.

Another aspect of the present invention is that the electro-magnetic coil assembly is relatively inexpensive to mass produce and to assemble accurately. The manufacturing process of the magnetic coil assembly is compatible with conventional well proven wafer or thin-film processing techniques, and provides highly efficient throughput for mass production.

According to the present invention the coil assembly includes a dielectric film , and a coil that is either bonded to, or formed on the dielectric film, and terminates in two contact pads for providing means for electrical connection to the coil. In one embodiment the dielectric film is made of alumina. The coil is surface mounted on the underside of an optical assembly and / or a slider by means of available techniques, such as an adhesive. In a specific application, the coil assembly includes two tool and alignment holes, one on each side of the coil, and an optical passage defined at the center of the coil for allowing a light beam to pass through.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention and the manner of attaining them, will become apparent, and the invention itself will be understood by reference to the following description and the accompanying drawings, wherein:

Fig. 1 is a fragmentary perspective view of a magneto-optical (MO) data storage system utilizing a magnetic coil assembly according to the invention;

Fig. 2 is an enlarged, fragmentary, perspective view of the magnetic coil assembly of Fig. 1, shown secured to a slider and / or an optical assembly forming part of the MO data storage system of Fig. 1;

Fig. 3 is an enlarged top plan view of the electro-magnetic coil assembly of Fig. 2;

Fig. 3A is a greatly enlarged cross-sectional side view of the coil assembly of Fig. 3, taken along line 3A-3A;

Fig. 4 is an enlarged, perspective, partly cross-sectional view of the electro-

2/9/08, EAST Version: 2.2.1.0

magnetic coil assembly of Fig. 3, along line 4-4;

Fig. 5 is an enlarged, cross-sectional view of the electro-magnetic coil assembly of Fig. 4, shown secured to slider and / or the optical assembly;

Figs. 6, 7, 8 and 9 are bottom plan views of the electro-magnetic coil assembly of Fig. 2, showing various attachments configurations of the electro-magnetic coil assembly to the slider and / or the optical assembly;

Fig. 10 is a cross-sectional view of a head formed of a slider and an optical assembly according to the present invention;

Fig. 11 is a greatly enlarged, fragmentary side view of the coil assembly shown secured to the slider according to one embodiment of the present invention; and

Fig. 12 is a greatly enlarged, fragmentary side view of the coil assembly shown secured to the slider according to another embodiment of the present invention.

Similar numerals refer to similar elements in the drawings. It should be understood that the sizes of the different components in the figures may not be in exact proportion, and are shown for visual clarity and for the purpose of explanation.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 1 illustrates a disk drive 10 comprised of a head stack assembly 12 and a stack of spaced apart optical or MO data storage disks or media 14 that are rotatable about a common shaft 15. The head stack assembly 12 is rotatable about an actuator axis 16 in the direction of the arrow C. The head stack assembly 12 includes a number of actuator arms, only three of which 18A, 18B, 18C are illustrated, which extend into spacings between the disks 14. The actuator arms 18A, 18B, 18C are generally identical.

The head stack assembly 12 further includes a block 19 and a magnetic rotor 20 attached to the block 19 in a position diametrically opposite to the actuator arms 18A, 18B, 18C. The rotor 20 cooperates with a stator (not shown) for rotating in an arc about the actuator axis 16. Energizing the coil (not shown) of the rotor 20 with a direct current in one polarity or the reverse polarity causes the head stack

2/9/08, EAST Version: 2.2.1.0

assembly 12, including the actuator arms 18A, 18B, 18C, to rotate about the actuator axis 16 in a direction substantially radial to the disks 14.

A head gimbal assembly (HGA) 28 is secured to each of the actuator arms, such as actuator arm 18A. The HGA 28 comprises a resilient load beam 33 and a slider 37 secured to the free end of the load beam 33. The slider 37 is also referred to herein as a support element since it supports an optical assembly 40 and / or an electro-magnetic coil assembly 44 (Fig. 2). The optical assembly 40 is illustrated by a block drawn in dashed lines, and is secured to the HGA 28 and in particular to the slider 37, for providing the required optical reading and writing beams.

The electro-magnetic coil assembly 44 is secured to the underside (or air bearing surface side) 46 of the slider 37, which is the surface facing the disk 14, and / or to the optical assembly 40. It should however be understood that the coil assembly 44 can be secured either to the slider 37 or to the optical assembly 40.

The details of the coil assembly 44 will now be described with reference to Figs. 3, 3A, and 4. The coil assembly 44 is comprised of an electrically conductive coil 50 formed of a length of electrical conductor, and is either deposited or formed on a film or substrate 52 by means of wafer processing techniques. The film 52 is formed of a dielectric film preferably made of alumina. It should however be clear that other suitable flexible materials (such as a flex circuit or film) or rigid dielectric materials (such as silicon) may alternatively be used. The film 52 is light weight and durable, and enables the coil assembly 44 to be readily handled, and assembled onto the slider 37 and / or the optical assembly 40. The thickness of the film 52 is approximately 4 microns, though other dimensions can optionally be selected. The film 52 is also referred to herein as a surface attachment layer.

As it can be appreciated, the coil assembly 44 has compact, low mass, and high field characteristics, and generates a large magnetic field intensity in the vertical direction. The coil assembly 44 further allows direct overwrite at a low flying height, with precise control of the focal plane of the optical assembly 40. The coil assembly 44 does not interfere with the vertical axis motion of the head, thus ensuring that the

focal plane of the optical assembly 40 coincides generally with a MO layer 53 (Fig. 5) of the disk 14.

The overall mass of the coil assembly 44 can range between approximately 10 micrograms to 100 micrograms. The size compactness of the coil assembly 44 allows for a more efficient design and results in a high magnetic field. The overall dimensions of the coil assembly 44 are significantly smaller than the slider underside 46. In addition, since the coil assembly 44 is mounted directly onto the slider 37 and / or the optical assembly 40, the flying height of the slider 37 is not significantly affected by the presence of the coil assembly 44, thus ensuring the precise control of the flying height of the slider 37 above the disk 14 and the precise control of the vertical axis motion. As used herein, "vertical axis motion" refers to the focusing axis (or optical path) of an optical beam generated by the optical assembly 40. In addition, the minimal thickness of the coil assembly 44 minimizes the overall z-height (i.e., the vertical height or inter-disk spacing) of the head stack assembly 12, thus enabling the disk drive 10 to accommodate an optimal number of disks 14 in a predetermined space.

The coil assembly 44 further includes two bonding pads 55, 56 for providing means for electrical connection to the coil 50. The bonding pads 55, 56 may be made of gold traces. The coil 50 is secured to the film 52 by means of three holding pads 61, 62, 63 for ensuring a firm connection of the coil 50 to the film 52. It should be clear to a person of ordinary skills in the field that a different number of holding pads may alternatively be used. The bonding pads 55, 56 are formed on the film 52 using available deposition techniques, and are connected to the terminals of the coil 50.

The coil assembly 44 also includes two or more generally identical, distally located tooling, alignment and handling holes 66, 67 formed in the film 52, one hole on each side of the coil 50. The holes 66, 67 facilitate the handling, alignment, and bonding of the coil assembly 44 onto the slider 37 and / or the optical assembly 40. In the embodiment illustrated in Fig. 3A, each tooling, alignment and handling hole,

i.e., 66 includes two metal rings: an upper ring 68, and a lower ring 69, that provide visual alignment and pattern recognition capability. The lower ring 69 is made of copper and is deposited onto the film 52, and the upper ring 68 is made of nickel iron and is coaxially overlaid over the lower ring 69 to define a central passageway 67A. The upper and lower rings 68, 69 are formed using available deposition techniques.

The coil assembly 44 is manufactured on a wafer substrate (not shown) by depositing a continuous base film of copper 71 (shown in dashed lines in Fig. 3). A continuous film of alumina, which eventually yields the film 52, is deposited on the base film 71 and the coil 50 is then formed on the film 52. The coil 50 and the film of alumina are then masked to produce an island having the final shape of the film 52, and excess alumina is etched away for exposing the copper base film 71. The copper base film 71 is then etched away and the island containing the film 52 is released from the substrate.

For purposes of illustration only, when the coil assembly 44 is used as part of the optical or MO disk drive 10, a central optical passage 70 is defined substantially at the center of the coil 50, for allowing an optical beam (e.g. a laser beam) 72 (Fig. 5) to pass through. In one embodiment the central optical passage 70 has a substantially circular contour and has its diameter vary between about 0.4 mil to about 1 mil, where one mil is equal to one thousandth of one inch. In another embodiment the central optical passage 70 has an elongated (e.g. elliptical) shaped contour. In still another embodiment the central optical passage 70 has a square or rectangularly shaped contour, with its sides dimensions varying between about 0.4 mil to about 1 mil, with the longer side being generally oriented substantially perpendicularly to the track direction of the disk 14 (i.e., radially relative to the disk 14), for allowing the inter-track excursion of the optical beam 72. Other dimensions and shapes can alternatively be selected, provided they do not interfere with the free passage of the optical beam 72.

Although the film 52 is illustrated as being substantially flat, it should be clear

that other shapes and configurations are possible. In the present example, the outer contour of part of the film 52 corresponds to the contour of the coil 50. The following exemplary dimensions for the coil assembly 44 are included for illustration purpose and are not intended to limit the present invention. The length "L" of the film 52 is approximately 31.5 mils. The width "W" of the film 52 is approximately 9 mils. The separation distance "S" between the two alignment holes 66, 67 is approximately 28.2 mils. The distance "S1" between the center of the alignment hole 66 and the central optical passage 70 is approximately 14.9 mils. The distance "S2" between the center of the alignment hole 67 and the central optical passage 70 is approximately 10 mils. The diameter of the alignment holes 66 and 67 is approximately 1 mil.

Some of the coil design characteristics will be included herein for the purpose of completeness of the description. The design objectives of the coil 50 are to meet or exceed the following requirements:

- Coil current: less than, or equal to approximately 70 mA.
- Magnetic field: greater than, or equal to approximately 300 Oersted.
- Coil Self-inductance: less than, or equal to approximately 200 nH.
- Capacitance: less than, or equal to approximately 5 pF.
- Resistance: less than, or equal to approximately 22 Ω.
- Input voltage: less than, or equal to approximately 7 V.

With reference to Figs. 4 and 5, the coil 50 generally includes a conductor 82 which is coiled, housed within a yoke 84, and encapsulated within an insulation layer 86. The optical or laser beam 72 passes through the central optical passage 70 for impinging upon the disk 14. The conductor 82 includes a plurality of multi-layered turns 93, for example 15 to 40 turns, and is made of a suitable electrically conductive material such as copper. While the conductor 82 is illustrated as having a square cross section, it should be understood that other appropriate shapes can be selected. The cross-sectional area of the turns 93 varies between approximately 2 μm and approximately 7 μm, and preferably between approximately 3 μm and

approximately 4.5 μm.

The turns 93 are encapsulated within the protective insulation layer 86, and are inter-spaced and separated by a distance varying between approximately 3 μm and approximately 10 μm, and preferably between approximately 5 μm and approximately 6 μm. The insulation layer 86 is made of a suitable dielectric material, such as photoresist material. The insulation layer 86 defines a tip 95 that extends beyond and underneath the tip 97 of the yoke 84. The tip 95, as illustrated in the Figs 4 and 5 is ring-shaped and concentric relative to the central optical passage 70 and to another optical opening 100 in the film 52. The shape of the optical opening 100 is preferably similar to the contour to the optical passage 70, and has either a diameter or a side ranging between approximately 15 μm and approximately 40 μm. Preferably, the diameter or side optical opening 100 ranges between approximately 20 μm and approximately 25 μm.

The tip 95 positions the yoke tip 97 relative to the disk 14, such that a light spot 101 formed by the laser beam 72 on the surface of the disk 14 coincides substantially with the maximum magnetic flux density (at point B) generated by the magnetic field on the MO layer 53. This allows for optimal polarization of the disk 14. While the inner surface 105 of the yoke 84 is shown as tapering inwardly, it should be understood that alternative configurations are also possible. For example, the inner surface 105 can be substantially straight or stepped.

In the embodiment shown in Fig. 5 the height of the tip 97 above the film 52 is approximately equal to the height of the first layer 110 of turns 93. It should however be understood that the height of the tip 97 can vary in order to provide optimal optical and magnetic performance of the coil assembly 44. In some designs it might be desirable to eliminate the tip 95 all together, and to have the yoke tip 97 extend to, or in close proximity to the optical opening 100 in the film 52.

The yoke 84 is made of a suitable ferromagnetic material such as nickel iron alloy (NiFe). The thickness of the yoke 84 may range between approximately 4 μm and approximately 6 μm. It should be clear that the quantities and dimensions

mentioned herein are simply for purposes of illustration and that other values may be used instead. In another embodiment, the coil 50 is at least partly encapsulated within an overcoat layer (not shown) for added protection and insulation. The overcoat layer provides a passage that coincides with the central passage 70 for allowing the optical beam 72 to pass through the coil assembly 44.

With reference to Figs. 2, and 5 through 9, the coil 50, the yoke 84 and / or the film 52 are surface mounted on the underside of the optical assembly 40 and / or the slider 37, by means of available techniques, such as adhesive 112.

Figs. 6, 7, 8 and 9 are bottom plan views of the coil assembly 44 showing various attachments configurations of the coil assembly 44 to the slider 37 and / or the optical assembly 40. For added clarity of illustration, the optical assembly 40 is shown exaggerated in dashed lines. Fig. 6 shows the segment of the coil assembly 44 containing the bonding pads 55, 56 secured to the optical assembly 40 and / or the underside 46, with the opposite segment of the coil assembly 44 remaining free.

Fig. 7 shows the segment of the coil assembly 44 containing the bonding pads 55, 56 secured to the optical assembly 40 and / or the underside 46. Fig. 8 shows the segment of the coil assembly 44 not containing the bonding pads 55, 56 secured to the optical assembly 40 and / or the underside 46, with the segment of the coil assembly 44 containing the bonding pads 55, 56 remaining free for providing convenient electrical access to the bonding pads 55, 56 from the top side of the coil assembly 44. This will enable electrical conductors to the bonding pads 55, 56 to be placed conveniently outside the space defined by the flying height of the slider 37, thus further assisting in the reduction of the flying height. Fig. 9 shows the segment of the coil assembly 44 containing the bonding pads 55, 56 secured to the optical assembly 40 and / or the underside 46, with the opposite segment of the coil assembly 44 secured to a tab 120. The tab 120 is eventually broken away and separated from the coil assembly 44.

With reference to Figs. 10, 11, there is illustrated a head 119 formed of slider 37 and the optical assembly 40, and which accommodates an optical fiber 116. In this

specific embodiment, the optical assembly 40 includes a mirror 121 mounted on the slider 37 for reflecting the optical beam 70 to and from the optical fiber 116. The optical assembly 40 further includes a quarter-wave plate 122 and a lens 124 that are mounted within a vertical channel 160 formed in the trailing edge 171 of the slider 37. The coil assembly 44 is mounted within a recess 173 for aligning the coil assembly 44 relative to the slider air bearing surface 46. In one embodiment the underside 115 of the coil assembly 44 is coplanar (i.e., flush) with the slider underside 46. In another embodiment the underside 115 is recessed relative to the slider underside 46.

With reference to Fig. 12, one of the slider sides, for example the trailing edge 171, contains a lateral channel or groove 175 into which the coil assembly 44 is inserted and retained. In this embodiment, the substrate 52 (or tab 120) acts as a carrier for the coil 50, so as to facilitate the assembly of the coil 50 to the slider 37.

It should be understood that the geometry, compositions, and dimensions of the elements described herein may be modified within the scope of the invention. For instance, the inventive concept of the present invention may be extended to optical and magneto-optical media with multiple data layers. Other modifications may be made when implementing the invention for a particular environment. In addition, while the coil assembly 44 has been described in connection with disk drives, it should be clear that the coil assembly 44 may alternatively be used in various other applications, including but not limited to antennas for wireless communications (i.e., cellular telephones), micro-electromechanical sensors (MEMS), miniaturized inductors for generation of motion, magnetic storage devices, etc.

What is claimed is:

1. A coil assembly for use in an optical or a magneto-optical data storage system including a support element having an underside, the coil assembly comprising:

a substrate;

a coil formed by means of a wafer processing technique on said substrate; and

said electro-magnetic coil being surface mounted at least in part on the underside of the support element.

2. A coil assembly according to claim 1, wherein said coil includes a magnetic yoke; and

wherein said yoke is surface mounted on an underside of the support element.

3. A coil assembly according to claim 1 or 2, wherein said substrate includes a dielectric film.

4. A coil assembly according to claim 3, wherein said substrate is made of any of: alumina or silicon.

5. A coil assembly according to any of claims 1, 2, 3, or 4, wherein each of said substrate and said coil includes an optical passage for allowing an optical beam to pass through the coil assembly.

6. A coil assembly according to claim 5, wherein said optical passage is defined at substantially a geometric center of said coil.

7. A coil assembly according to any of claims 1, 5, or 6, further including a tooling hole formed in said substrate.

8. A coil assembly according to claim 8, wherein said film is substantially flat.

9. A coil assembly according to claim 8, wherein said film is generally rectangularly shaped and has a length of approximately 30 mils and a width of approximately 8 mils.

10. A coil assembly for use in an optical or a magneto-optical data storage system including an optical assembly, the coil assembly comprising:

a substrate;

an coil formed by means of a wafer processing technique on said substrate; and

said coil being surface mounted on the optical assembly.

11. A coil assembly according to claim 10, wherein said coil includes a magnetic yoke; and

wherein said yoke is surface mounted on the optical assembly.

12. A coil assembly to be secured to a support element having an underside, the coil assembly comprising:

a substrate;

a coil formed by means of a wafer processing technique on said substrate; and

said coil being surface mounted at least in part on the underside of the support element.

13. A coil assembly according to claim 12, wherein said coil includes a magnetic yoke; and

wherein said yoke is surface mounted on an underside of the support element.

14. A coil assembly according to any of claims 1, 10, or 12, wherein said

substrate includes a substantially rigid dielectric film.

15. A method of securing a coil assembly to an optical or a magneto-optical data storage system including a support element having an underside, the method comprising:

forming a coil on a substrate by means of a wafer processing technique; and

mounting said coil on the underside of the support element.

16. A method according to claim 15, wherein the step of forming said coil includes forming a yoke; and

wherein the step of mounting said coil includes surface mounting said yoke on the support element.

17. A method of securing a coil assembly to an optical or a magneto-optical data storage system including an optical assembly, the method comprising:

forming a coil on a substrate by means of a wafer processing technique; and

mounting said coil on said optical assembly.

18. A method according to claim 17, wherein the step of forming said coil includes forming a yoke; and

wherein the step of mounting said coil includes surface mounting said yoke on said optical assembly.

19. A method of securing a coil assembly to a support element having an underside, comprising:

forming a coil on a substrate by means of a wafer processing technique; and

mounting said coil on the underside of the support element.

20. A method of securing a coil assembly to an optical assembly, comprising: forming a coil on a substrate by means of a wafer processing technique; and mounting said coil on the optical assembly.

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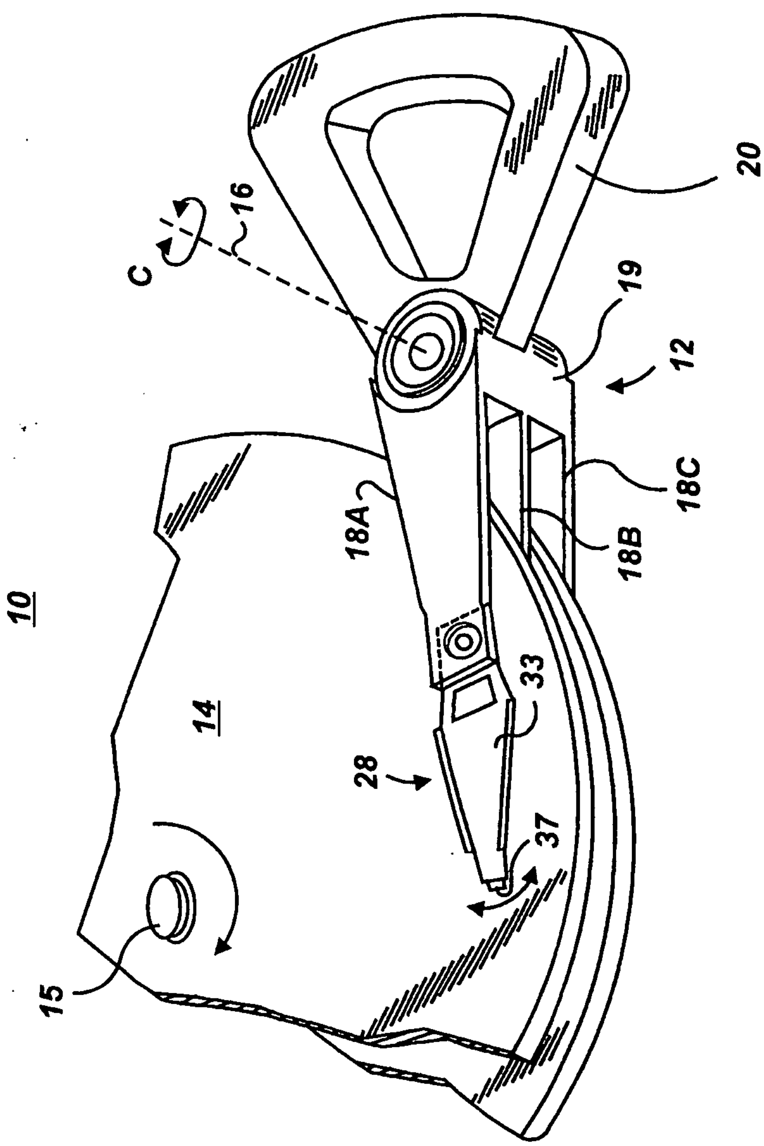

FIG. 1

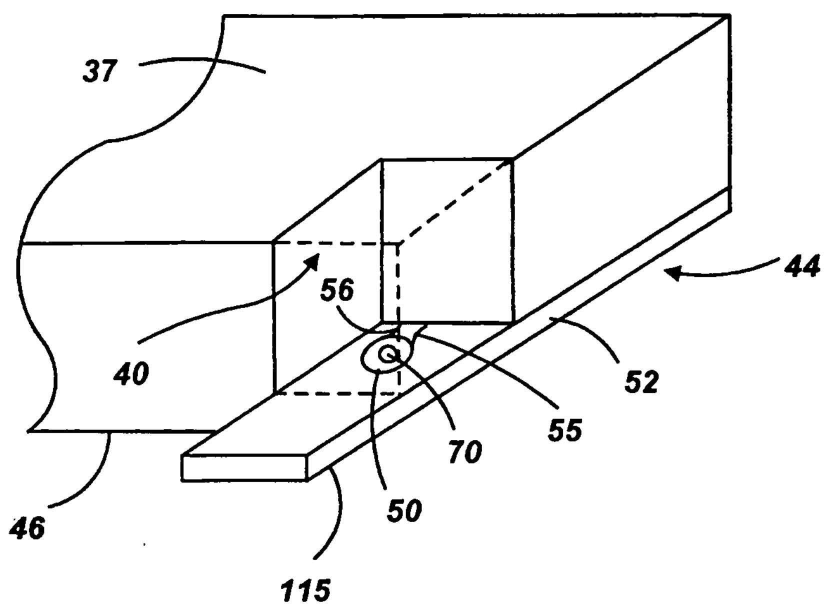

FIG.2

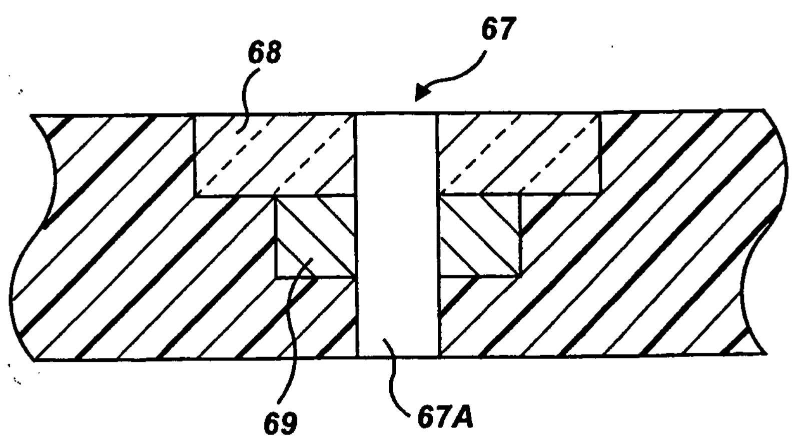

FIG. 3A

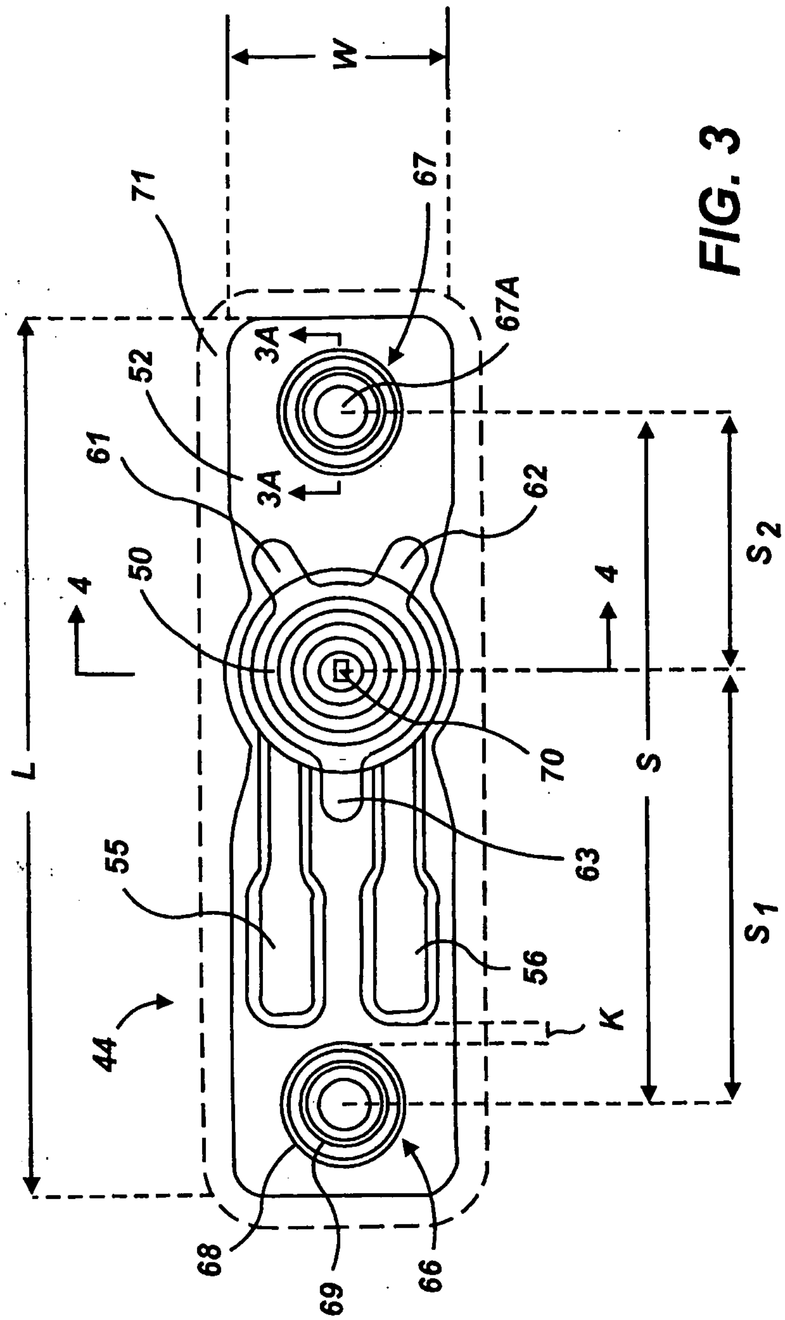

FIG. 3

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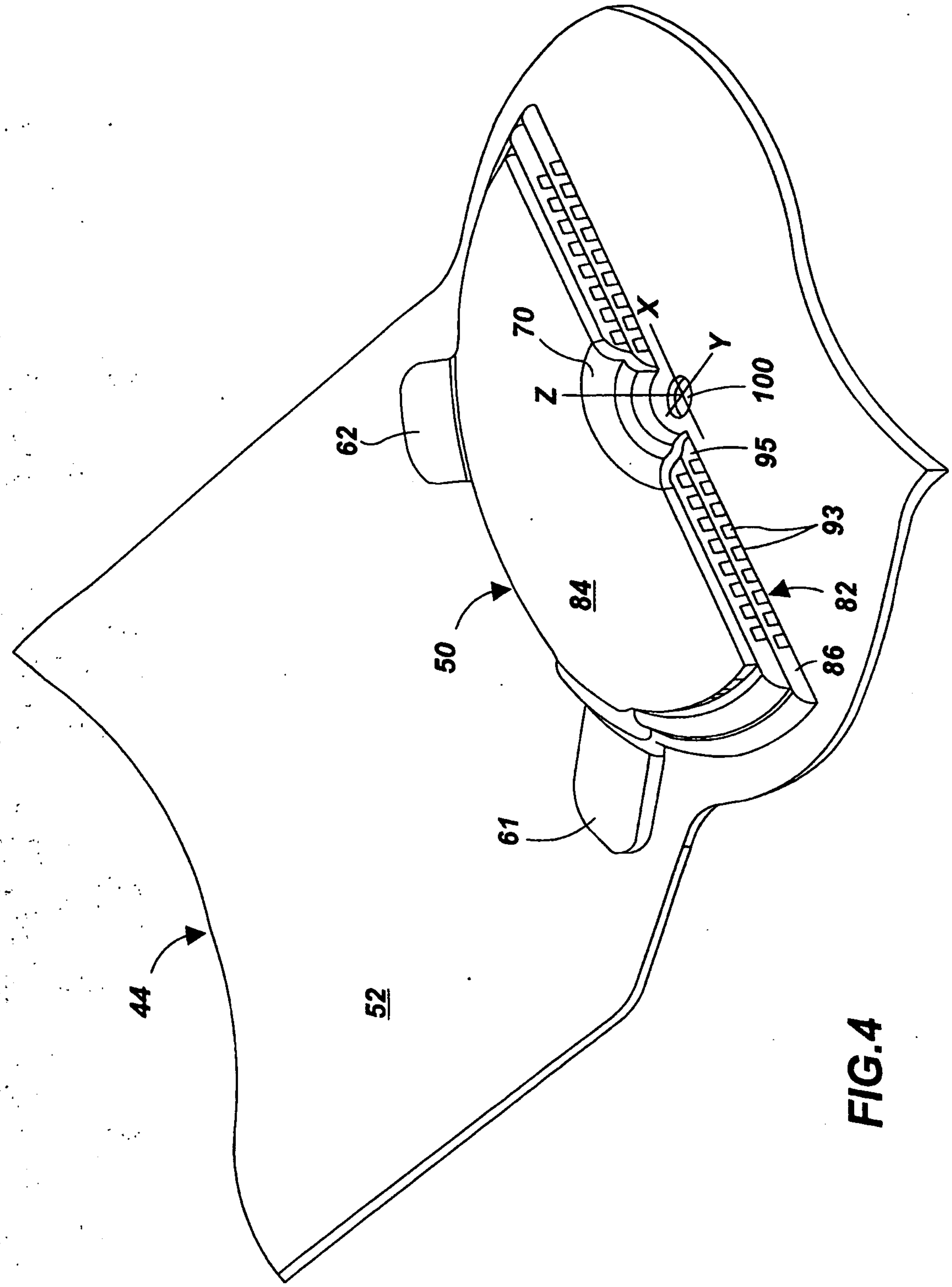
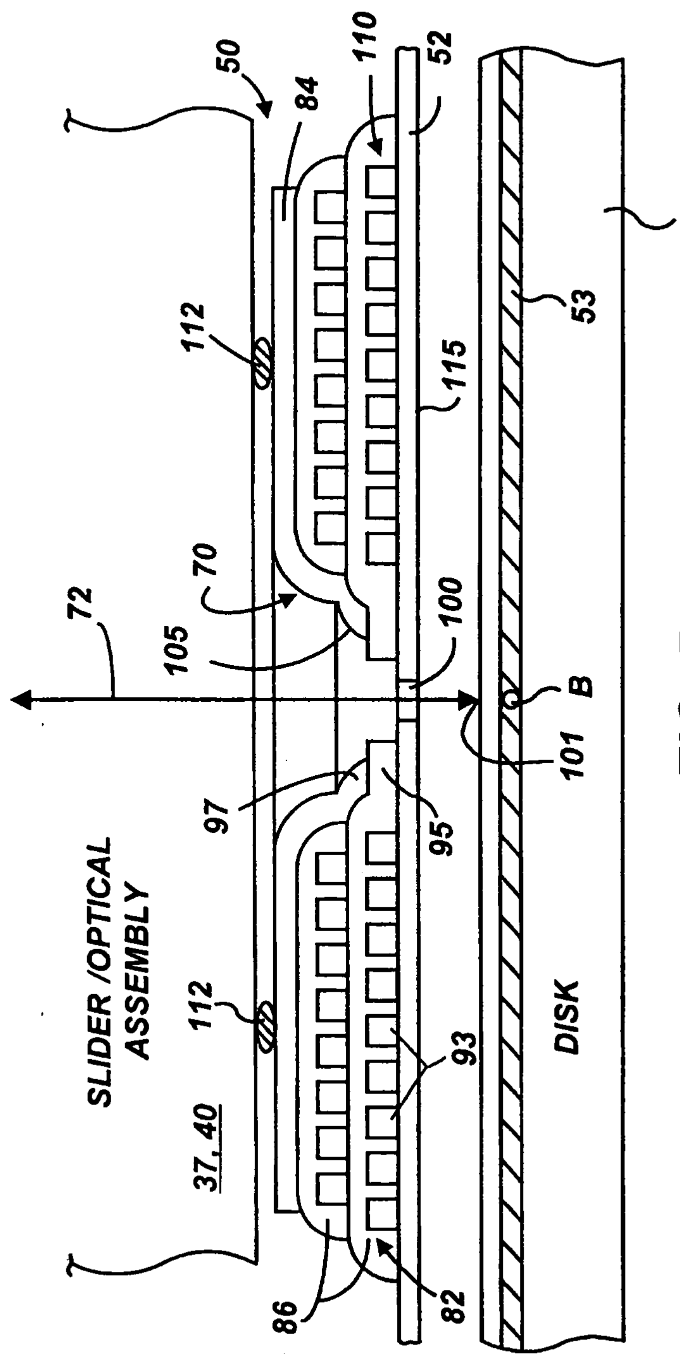


FIG.4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37, 40
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93
DISK
86
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FIG. 5

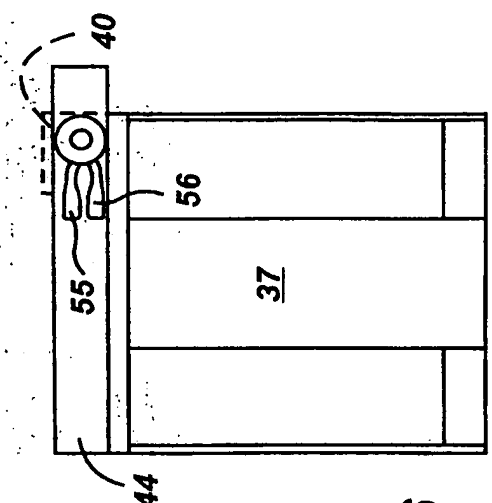

FIG. 6

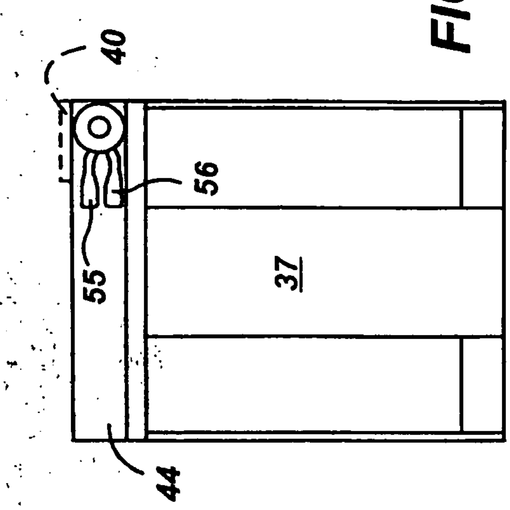

FIG. 7

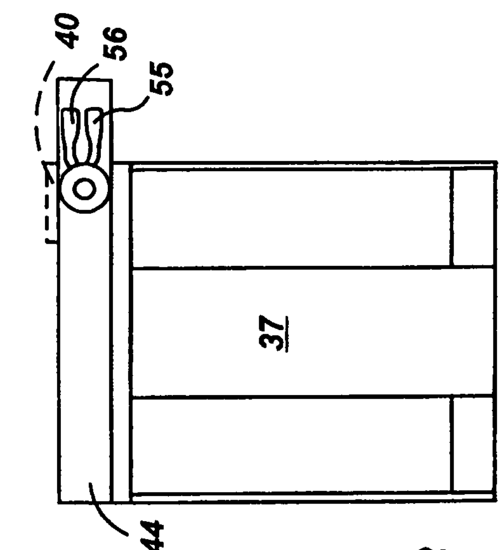

FIG. 8

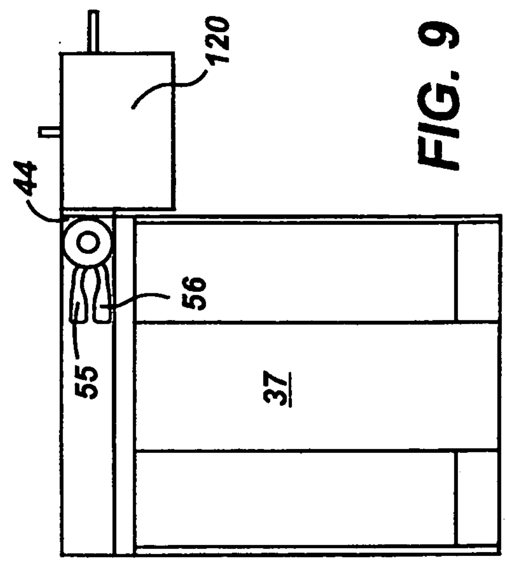

FIG. 9

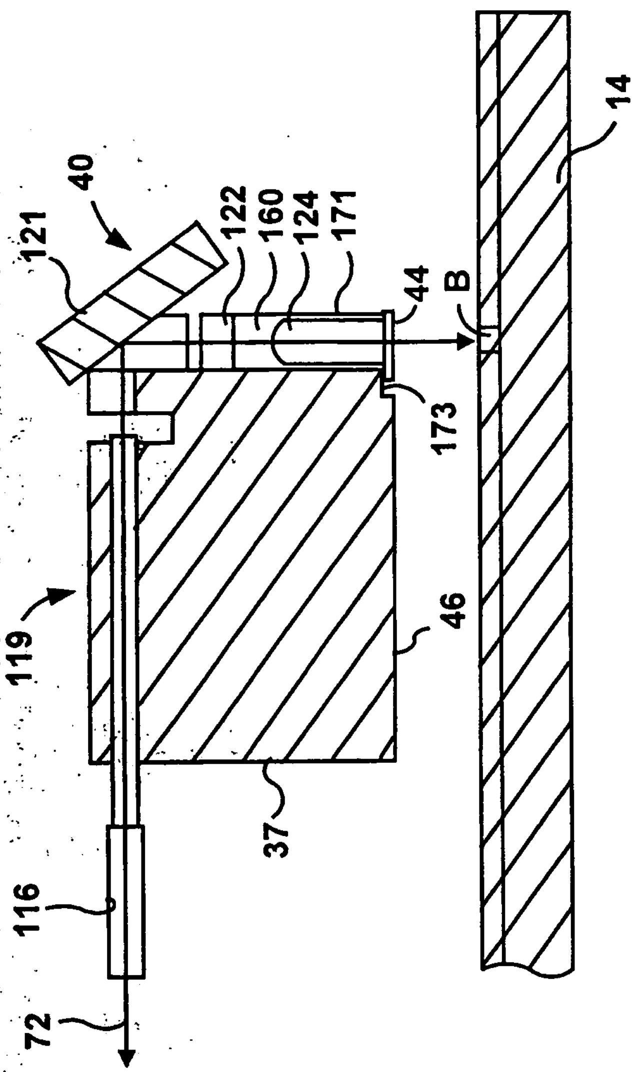

FIG. 10

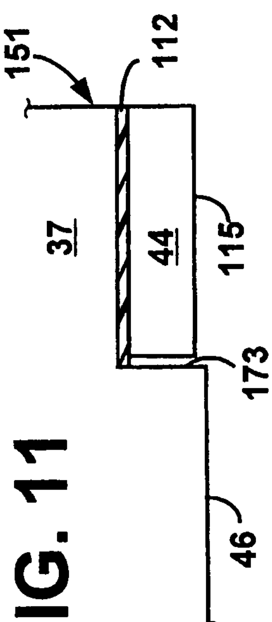

FIG. 11

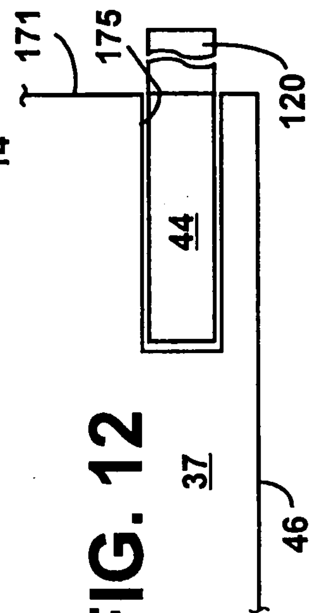

FIG. 12